DISTRIBUTION PLANNING STANDARDS AMMENDMENTS

(Due to New International Low Voltage Standard - 400/230 V)

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(Due to New International Low Voltage Standard - 400/230 V)

Introduction:

In compliance and pursuance to the Council of Ministers decree No. (324) dated 20/9/1431 H regarding the approval of changing the existing distribution low voltage in the Kingdom of Saudi Arabia to be in line with the international low voltage standard 400/230 V, SEC is in need to review all its existing standards due to this change in voltage level.

This document shows the necessary amendments (only due to new international low voltage standard - 400/230 V) in all the existing SEC Distribution Planning Standards (DPS's). These amendments should be read in conjunction with respective existing Distribution Planning Standards (DPS's) until the completion of revising of these standards which is under process by recently constituted committee.

This document includes only the clauses which require any necessary amendment due to new international low voltage standard 400/230 V with its complete text, title(s) and numbering of clauses, tables and pages as it is in the respective existing Distribution Planning Standards (DPS's). The specific changes within the clause are highlighted and shown in red color.

The guidelines/standards which have been reviewed in this document are :

1) **DPS** : Distribution Planning Standards (Rev. 01, Dated: March 2004)
2) **DPS-06** : Multi Source Two Voltage Or One Voltage Supplies, Including More Than One MVA (Rev. 01, Dated: April 2004)
3) **DPS-07** : Procedures for Supply to Customers more than 400 A on LV (Rev. 01, Dated: July 2008)
   إجراءات تغذية المشتركين الذين تستوجب تغذيتهم تركيب قواطع تتجاوز سعاتها 400 أمبير على الجهد المنخفض

Summary of Amendments

Referred Standard	Clause No.	Clause Title	Referred Page
DPS : **Distribution Planning Standards (Rev. 01, Dated: March 2004)**			
DPS	(1.5)	Harmonics	15 of 90
DPS	(1.9)	Standard Distribution Voltage	16 of 90
DPS	(1.10.1)	Voltage Drop Allocation	17 of 90
DPS	(1.10.2)	Standard Utilization Voltage	18 of 90
DPS	(3.1)	Introduction	37 of 90
DPS	(3.4) - d	Load Estimation Procedures	41 of 90
DPS	(3.5.1)	Underground Network Configuration	42 of 90
DPS	(3.6)	Calculation of Voltage Drop (V.D.)	45 of 90
DPS	(3.7.1) - a	Distribution Substation Type \ Package Unit	47 of 90
DPS	(3.7.1) - c	Distribution Substation Type \ Pole Mounted Transformers	48 of 90
DPS	(3.8)	Low Voltage Cable/Conductors	50 of 90
DPS	(3.10)	New Plot Plan	51 of 90
DPS	(4.2.3)	Criteria / Short Circuit Performance	53 of 90
DPS	(4.3.2)	Criteria / Voltage Regulator Placement	55 of 90
DPS	(4.3.7) - c	Calculation technique \ Example of the Manual Technique \ step 2	60 of 90
DPS-06 : **Multi Source Two Voltage Or One Voltage Supplies, Including More Than One MVA (Rev. 01, Dated: April 2004)**			
DPS-06	(3.1.1)	One MVA and Above	4 of 6
DPS-07 : **إجراءات تغذية المشتركين الذين تستوجب تغذيتهم تركيب قواطع تتجاوز سعاتها 400أمبير على الجهد المنخفض** **Procedures for Supply to Customers more than 400 A on LV (Rev. 01, Dated: July 2008)**			
DPS- 07	---	مقدمة	2 of 5

AMMENDMENTS

(Due to New International Low Voltage Standard - 400/230 V)

for

DPS

DISTRIBUTION PLANNING STANDARDS

(Rev. 01, Dated: March 2004)

DPS 1.5 Harmonics **Page 15 of 90**

The level of harmonics in the power system shall not exceed the values, listed in Table - 1.1 (a) and Table - 1.1 (b), on a continuous basis.

Table – 1.1 (a)
Maximum Continuous Harmonic Levels for Standard Voltages

Nominal Voltage	Total Harmonics Voltage Distortion (%)	Individual Harmonic Voltage Distortion (%)	
		Odd	Even
230 - 400 V	5.0	4.0 for N < 14 1.5 for N ≥ 14	2.0
13.8 KV	4.0	3.0	1.75
33 KV	3.0	2.0	1.0

Table – 1.1 (b)
Maximum Continuous Harmonic Levels for Existing / Non-Standard Voltages

Nominal Voltage	Total Harmonics Voltage Distortion (%)	Individual Harmonic Voltage Distortion (%)	
		Odd	Even
* 127 – 380 V	5.0	4.0 for N < 14 1.5 for N ≥ 14	2.0
* 11 KV	4.0	3.0	1.75
* 34.5 KV	3.0	2.0	1.0

*Existing voltage, but non-standard voltage.

Note:

- N is the harmonic order, or multiple of the fundamental frequency.
- Voltage distortion is expressed as a percentage of the fundamental voltage.
- The indicated values refer to maximum continuous levels.

DPS 1.9 Standard Distribution Voltage **Page 16 of 90**

The voltages listed in Table – 1.2 shall be used as standard service voltages at the interface with power customers. The service voltage shall be maintained within the range defined by the indicated lowest and highest values, under steady state and normal system conditions and over the full loading range of the system.

Where two voltages are listed e.g. , 400/230 V or 220/127 V the lower value refers to the phase to neutral voltage. All other values are phase-to- Phase voltages.

Table - 1.2
Standard / Existing Service Voltages

Nominal Voltage	Lowest Voltage	Highest Voltage
400/230 V	380/218 V	420/242 V
13.8 KV	13.11 KV	14.49 KV
33 KV	31.35 KV	34.65 KV
* 380/220 V	360/209 V	400/231 V
* 220/127 V	209/120 V	231/134 V
* 11 KV	10.45 KV	11.55 KV
* 34.5 KV	32.78 KV	36.23 KV
* 69 KV	65.55 KV	72.45 KV
Percentage Limits	- 5.0 %	+ 5.0 %

*Existing voltages, but non-standard voltage.

DPS 1.10.1 Voltage Drop Allocation **Page 17 of 90**

(a) LV Customers :

The Utility voltage drop allocations listed in Table - 1.3 shall be used as guideline voltage drops over the power system components supplying a low voltage customer. The additional voltage drop in the customer's wiring shall not exceed the value indicated.

Table – 1.3
Voltage Drop Allocations

Power System Component	Voltage Drop %
Utility:	
Primary System (MV) :	
Substation Voltage Regulator Bandwidth	1.0
Primary Feeders	1.5
Distribution Transformer	2.5
Secondary System (LV) :	
Secondary Feeder	3.5
Service Feeder	1.5
Total Service Drop	**10.0**
Customer:	
Customer Wiring (To furthest point of utilization)	2.5
Total Utilization Drop	**12.5**

DPS 1.10.2 Standard Utilization Voltage **Page 18 of 90**

Table – 1.4
Standard Utilization Voltages

Nominal Voltage	Lowest Voltage	Highest Voltage
400/230 V	370/213 V	420/242 V
13.8 KV	12.8 KV	14.5 KV
33 KV	30.5 KV	34.7 KV
* 220/127 V	203/117 V	231/134 V
* 380/220 V	352/203 V	400/231 V
* 11 KV	10.18 KV	11.55 KV
* 34.5 KV	31.91 KV	36.23 KV
* 69 KV	63.83 KV	72.45 KV
Percentage Limits	- 7.5%	+ 5.0%

* Existing voltage, but non-standard voltage.

Notes:

Refer to details of voltage drop allocations. Where two voltages are listed, the lower value refers to the phase to neutral voltage. All other values are phase-to-phase voltages. Existing locations where other voltages are currently in use shall be clearly defined. For such other voltages, the utilization voltage shall be maintained within the indicated percentage limits. Refer to details of voltages under exceptional conditions, in the event of an outage.

DPS 3.1 Introduction **Page 37 of 90**

This section deals with the estimation of the customer load , electrical design and layout of LV supply network to new load developments , to deliver the supply of electricity at the standard service voltage under all normal operating load and voltage conditions, and to maintain the defined standards.

The objective of this section is to determine the connected and demand load of residential, commercial, agricultural and industrial customers, and to calculate diversity factor for a group of customers fed from the same source. Also to find the maximum allowable distance from the substation to customer to maintain the maximum allowable voltage drop (5%) as in Table - 3.1 .

Table – 3.1
(Standard Service Voltages)

Nominal Voltage	Lowest Voltage	Highest Voltage
400/230 Volts	380/218 Volts	420/242 Volts
* 220/127 V	209/120 V	231/134 V
* 380/220 V	361/231 V	400/231 V
Percentage Limits	- 5.0%	+ 5.0%

* Existing voltage, but non-standard voltage.

(d) Calculate the demand load of the group of customer fed from the same source :

Customers with the same load (KVA)
Demand load = Sum of the MDL of the customers / D.F (of all customers) or multiply by coincidence factor.

Customers with different load (KVA)
Demand load = MDL of the largest customer + [Sum of the MDL of the remaining customer / D.F (of remaining customers)]

Example: Calculate the demand load of the following customers (Residential customers, 230 V) and the cable size to feed them.

Demand load = MDL of the largest customer on the cabinet + [Sum of the MDL of the remaining customers on the same cabinet / D.F (of remaining customers)]

Customer A 4 No. of KWH meters ..... 100 m2 each
Customer B 4 No. of KWH meters ..... 325 m2 each
Customer C 1 No. of KWH meter 450 m2

From covered area Table - the connected load for 100 m2 = 16 KVA
For 325 m2 = 50 KVA and for 450 m2 = 66 KVA

Max. Demand load = demand factor x connected load
=0. 5x16 = 8 KVA (customer A 4 No. of KWH meters)
= 0.5x50 = 25 KVA (customer B 4 No. of KWH meters)
= 0.5x66 = 33 KVA (customer C 1 No. of KWH meter)

Diversity factor from Table 3.3 for 8 customers is 1.589

Demand load = MDL largest +[(MDL1+MDL2+...)/D.F]
= 33 + [(4x8 +4x25)/1.589] =116.07 KVA

DPS 3.5.1 Underground Network Configuration **Page 42 of 90**

At present, different method of customer low voltage connections are in practice, i.e. Looping system, Tee joint, Direct connection, etc... which are detailed below, whereas direct connection and connect through Distribution Cabinet are SEC Standards and to be followed.

For the LV, Maximum allowable length from substation to customer is 250 meter for 220V and 420 meter for 380 V - 400 V to maintain the maximum allowable voltage drop (5%).

DPS 3.6 Calculation of Voltage Drop (V.D) **Page 45 of 90**

For a particular supply voltage, the voltage drop from the supply point to the customer interface depends on various factors such as customer demand, length and size of feeder and power factor. A commonly used formula for voltage drop is provided at section 2. That formula modified to:

$$\%V.D. = \frac{KVA \times L}{K}$$

Where "KVA" is three phase load in KVA, "L" is length of the cable in meter and "K" is a constant shown in Table below:

Cable/Conductor Size	K		
	Standard Voltage	For Non-Standard Voltage(s)	
	400 V	220 V	380 V
4 x 300 mm^2 (AL)	10983	3322	9912
4 x 185 mm^2 (AL)	7648	2313	6902
4 x 70 mm^2 (AL)	3311	1001	2988
4 x 50 mm^2 (AL)	2347	710	2118
Quadruplex Cable 3(1x120) + 1 x 120 mm^2	3940	1192	3556
Quadruplex Cable 3(1x50) + 1 x 50 mm^2	2347	710	2118

The formula used to calculate the value of "K" constant which required for voltage drop calculations is :

$$K = \frac{V^2}{100\,(R \cos \Phi + X \sin \Phi)}$$

Where:
V = Three phase supply voltage in volts at sending end
R = Resistance of conductor in ohms per kilometer
X = Inductive resistance of conductor in ohms per kilometer
Φ = Angle of supply

Above Voltage Drop calculations are based on 3- Phase balance system.
For "K" calculation, "Cos Φ" is taken as 0.85 and values of Resistance and Reactance are taken from Table - 1.9 & Table - 6 in Appendix - A of Distribution Planning Standard (DPS).

DPS 3.7.1 Distribution Substation Type **Page 47 of 90**

(a) Package Unit :

The package unit substation is the preferred type and commonly used substation in SEC because of its convenience to install and occupy lesser spaces. This consists of Ring Main Unit, distribution transformer and Low Voltage Distribution Board combined in a single unit. Characteristics of the available package unit substation are as follow:

P.U Rating (KVA)	Number of Secondary Feeder Outlets	Voltage Ratio	
		Primary	Secondary
500	6/8	13.8 KV	400/230 V
1000	8/12	13.8 KV	400/230 V
1500	8/16	13.8 KV	400/230 V

(c) Pole Mounted Transformers:

The standard distribution substation for overhead system is a pole mounted transformer with secondary LV Distribution Cabinet. These are commonly used in rural areas where loads are located scatteredly.
Sizes & Characteristics of the available Transformer units are as follows:

Underground		Overhead		Voltage Ratio	
Size	L.V Feeder	Size	L.V Feeder	Primary	Secondary
300	4	50	2	33 KV , 13.8 KV	400/230 V
500	8	100	4	33 KV , 13.8 KV	400/230 V
1000	12	200	4	33 KV , 13.8 KV	400/230 V
1500	16	300	4	13.8 KV	400/230 V

DPS 3.8 Low Voltage Cables/Conductors **Page 50 of 90**

Following shall be considered for selecting cable size
(a) Size shall be selected based on demand load.
(b) Rating of cable/conductor is shown in the table - 3.4

Table – 3.4

Size of Cable	Current Rating per phase
4x70 mm2 Al.	135 Amps.
4x185 mm2 Al.	230 Amps.
4x300 mm2 Al.	310 Amps.
Size of Overhead Conductor	**Current Rating per phase**
120 mm2 Al. Quad.	270 Amps.
50 mm2 Al. Quad.	185 Amps.

Convert the demand load unit from KVA to Amperes to determine the size of the cable. For 220 V multiply by 2.6243 , for 380 V multiply by 1.5193 and for 400 V multiply by 1.4434.

DPS 3.10 New Plot Plan **Page 51 of 90**

The planning engineer should study the plan and details given by municipality regarding utilization of plots. Following procedure shall be adopted for the electrification of plans :

(a) Estimation of the plots load as per class of plot, percentage of construction and number of floors.

(b) Number of Substation required will be based on demand load where following points will be considered :

1 - Cable length shall not exceed 420 meters in (400/230 V) system.
2 - No crossing of 36 meters road shall be allowed.
3 - Voltage drop shall in standard limit (5 %).
4 - Transformer loading shall not exceed 80 %.
5 - The medium voltage cable shall be without hindrance and on clear routes (i.e asphalted or leveled roads).

DPS 4.2.3 Criteria / Short Circuit Performance **Page 53 of 90**

The underlying factors provide the conditions and criteria under which equipment performance study is undertaken.

(a) Short circuit calculation will be based on SEC standard.
(b) Short circuit duration is one second.
(c) The fault level at the customer interface does not exceed the values indicated in Table 4.1.
(d) Fault calculations shall be based on the highest voltages at each system level.
(e) MVA levels are calculated for the highest system voltage at each level.
(f) The distribution feeders radiate from only one grid station. There is no other source of power feeding into the distribution circuits.

Table 4.1
(Short Circuit Level)

System Voltage - Nominal	Short Circuit Level (1 Second)	
	kA	MVA
33 kV	25	1560
13.8 kV	20	527
400 V Consumer Interface Load		
< 500 KVA	20	14
> 500 KVA	30	21
*** 380 V Consumer Interface Load**		
< 500 KVA	20	14
> 500 KVA	30	21
*** 220 V Consumer Interface Load**		
< 152 KVA	21	8.4
> 152 KVA	45	18

* Existing voltage, but non-standard voltage.

DPS 4.3.2 Criteria / Voltage Regulator Placement **Page 55 of 90**

(a) Standard Distribution Voltages and Ranges:

The following voltages and their associated ranges are the proposed voltages by SEC that will be standard throughout the Kingdom of Saudi Arabia :

Nominal Voltage	Lowest Voltage	Highest Voltage	Standby Minimum
400/230 V	380/218	420/242	370/213 V
13.8 KV	13.1 kV	14.55 kV	12.80 kV
33 KV	31.4 kV	34.7 kV	30.525 kV
* 220/127 V	209/120 V	231/134 V	203/117 V
* 380/220 V	360/209 V	400/231 V	351/203 V
* 11 KV	10.45 kV	11.55 kV	10.175 kV
* 34.5 KV	32.78 kV	36.23 kV	31.90 kV
Percentage Limits	- 5.0 %	+ 5.0 %	- 7.5 %

(*) Non-standard but exist in SEC

A further 2.5% voltage drop is expected within the customer's wiring to give a normal utilization voltage drop of –10% for which the customer's equipment must be selected and designed for.

DPS 4.3.7 Calculation technique **Page 60 of 90**

(c) Example of the Manual Technique :

Step 2 :

For residential customers, the voltage needs to be maintained in the range of ±5% of the nominal voltage with a 3.0% allowance for transformer voltage drop and 5% for secondary service voltage drop.

For ideal case and without raising Tap changer of the distribution Transformer the minimum voltage of consumer must be (-5%) from the nominal voltage e.g = 95 %.

The equivalent voltage primary must be =95+3+5=103%.

To cover the voltage in transformer & secondary/service drop then the voltage must be 103+1.5+1=105.5% to cover V.D in segment AB, BC but we can not raise voltage more than 5%.

If the VR is to be located just prior to node A then the regulator voltage must be established at 105% to meet all feeder requirements at the system nominal voltage.

AMMENDMENTS

(Due to New International Low Voltage Standard - 400/230 V)

for

DPS-06

Multi Source Two Voltage Or One Voltage Supplies, Including More Than One MVA

(Rev. 01, Dated: April 2004)

Such supplies from more than one LV/MV transformer can be extended under the following conditions :

a) **LV supply voltages** shall be at any two voltages:

220/127V, 380/220V, 400/230 V, 480/277V.
(480/277V is applicable only for areas where 480/277V already exists).

b) **Primary voltage** of transformers shall be any one of the following:

11kV, 13.8kV, 33kV, 34.5kV
(11kV or 34.5kV is applicable only for areas where 11kV or 34.5kV already exists).

c) **Substations**

- Dedicated transformers/package units/unit substations in insets or rooms along with switchgear as applicable shall be used.
- Separate insets or rooms shall be used for each secondary voltage of transformer/package unit/unit substation.

d) **Metering**

Customers metering shall be based on Customer Services Manual.

e) **Undertaking from Customers**

Customer shall sign an undertaking for his responsibility for the following (see attached undertaking) :

- Separate conduits shall be used for cables/wiring of each voltage supplies.
- Sockets/outlets shall be installed only for one voltage.
- Changeover switches shall be used for all standby supplies.
- SEC transformers shall not be run in parallel.

- Customers shall provide at NOC/Application stage as well as at the time of commissioning a certificate along with wiring drawings from an independent engineering consultant stating that all wiring in the building is verified/checked and found ok for all above points.
- During emergency, SEC shall provide back - up supply for one supply voltage (220 or 380 or 400V or 480V), whichever is dominant in that location subject to the availability of redundant power at that location.
- Customers shall be fully responsible for all consequences resulting in from such paralleling of transformers and using such dual voltage supplies.

AMMENDMENTS

(Due to New International Low Voltage Standard - 400/230 V)

for

DPS-07

Procedures for Supply to Customers more than 400 A on LV

إجراءات تغذية المشتركين الذين تستوجب تغذيتهم تركيب قواطع تتجاوز سعاتها 400 أمبير على الجهد المنخفض

(Rev. 01, Dated: July 2008)

يتم حاليا تغذية المشتركين الذين تستوجب تغذيتهم تركيب قواطع تتجاوز سعاتها 400 أمبير على الجهد المنخفض بطرق وأساليب مختلفة بين قطاعات التوزيع بالمناطق كما أن متطلبات التغذية التي على الشركة والمشترك توفيرها وحدود مسئولية كل طرف تختلف من منطقة إلى أخرى.

وقد تم إعداد هذا الإجراء من اجل توحيد طريقة ومتطلبات التغذية على الجهد المنخفض (220/127 أو 380/220 أو 400/230 فولت) للمشتركين الذين تستوجب تغذيتهم تركيب قواطع تتجاوز سعاتها 400 أمبير وكذلك مسئولية كل طرف (الشركة والمشترك) مع الأخذ بعين الاعتبار أفضل الأساليب المستخدمة حاليا في قطاعات التوزيع.